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THE EFFECT OF WHITE MUSTARD PROXIMITY ON BROAD BEAN INFESTATION WITH BLACK BEAN APHID (*Aphis fabae* SCOP.)

Summary

Objective of the study consisted in the evaluation of the effect of white mustard as a companion plant in the cultivation of broad bean, cultivar Bartek, on the level of plant infestation with black bean aphid Aphis fabae Scop., and also on the occurrence of its natural enemies. The field experiment comprised the following objects: control - broad bean, Bartek cv. as a homogenous crop, sown at 50 cm x 10 cm spacing; broad bean spaced 60 cm x 10 cm with white mustard as the crop intersown between the rows and broad bean spaced 50 cm x 10 cm, with a 50 cm wide mustard stripe surrounding the plot (in this case the width of broad bean stripes was 3 m). Broad bean cultivation in combination with intercropping white mustard, as well as in the form of surrounding sowing contributed to a significant decrease in black bean aphid abundance on the broad bean plants. The effect was visible mainly during the final period of the pest occurrence. The analysis of the occurrence of natural enemies of A. fabae demonstrated a strong relationship between the number of adult Coccinellidae with the number of aphid and their highest numbers in the homogenous broad bean cultivation. On the other hand, the predator to prey ratio in the case of larval stages of the major aphid predators, i.e. Syrphidae and Coccinellidae was more favorable in the presence of mustard as the companion plant.
***Key words**: intercropping, Vicia faba* L. *ssp. maior, Sinapis alba* L.*, aphids, aphid predators*

WPŁYW SĄSIEDZTWA GORCZYCY BIAŁEJ NA STOPIEŃ OPANOWANIA BOBU PRZEZ MSZYCĘ BURAKOWĄ (*Aphis fabae* SCOP.)

Streszczenie

Celem pracy była ocena wpływu gorczycy białej, jako rośliny towarzyszącej, w uprawie bobu (Vicia faba L.*), odmiany Bartek na stopień opanowania roślin przez mszycę burakową (Aphis fabae Scop.), jak również na występowanie jej wrogów naturalnych. Doświadczenie obejmowało następujące obiekty: kontrola - bób w uprawie jednogatunkowej wysiany w rozstawie 50 cm x 10 cm; bób w rozstawie 60 cm x 10 cm z gorczycą wsianą między rzędami oraz bób w rozstawie 50 x 10 cm obsiany dookoła pasem gorczycy o szerokości 50 cm (szerokość pasów bobu wynosiła w tym przypadku 3 m). Uprawa bobu wspólnie z gorczycą białą w międzyrzędziach, jak i w postaci obsiewu, przyczyniła się do istotnego zmniejszenia liczebności mszycy burakowej na roślinach bobu. Efekt ten widoczny był głównie w końcowym okresie występowania szkodnika. Analiza występowania wrogów naturalnych mszycy burakowej wykazała silny związek liczebności dorosłych Coccinellidae z liczebnością mszyc i ich najliczniejsze występowanie w uprawie jednogatunkowej bobu. Natomiast stosunek liczbowy drapieżcy do ofiary w przypadku stadiów larwalnych głównych afidofagów, tj. Syrphidae i Coccinellidae korzystniej kształtował się w obecności gorczycy jako rośliny towarzyszącej.*
***Słowa kluczowe**: uprawa współrzędna, Vicia faba* L. *ssp. maior, Sinapis alba* L.*, mszyce, drapieżcy mszyc*

1. Introduction

Introduction to the main crops of companion plants, especially those producing great amounts of pollen, constitutes the perfect method enabling the increase of biodiversity and stability of the ecological balance in agrocenoses [9, 10, 14]. It can constitute an alternative for the plant protection with the use of chemical products, particularly in ecological management systems [11]. White mustard (*Sinapis alba* L.) is characterized by a series of features, which indicate its usefulness for this purpose. It is famous for its inhibiting effect on the feeding of certain soil pests, e.g. sugarbeet nematode (*Heterodera schachtii* Schmidt.) [15]. Its root secretions, due to their allelopathic properties, have been studied for the possible use for pro-ecological herbicides [12]. The introduction of white mustard to the cultivation of e.g. faba bean leads to increase of root concentration in deeper layers of soil and therefore to potentially better use of nutrients. However, little information has been collected on the effect of this plant on the occurrence of pests on the above-ground parts of crops. White mustard cultivated next to pea (*Pisum sativum* var. *arvense*) [16] and broad bean (*Vicia faba* L. ssp. *maior*) [4] had an inhibitory effect on the feeding of pea weevils (*Sitona* spp.). Moreover, combined with lacy phaceila, it significantly limited the feeding of pea thrips (Thripidae, Thysanoptera) on pea (*Pisum sativum* L.) and decreased population of the pest [17]. The mechanism of this white mustard effect may stem from the fact that finding the host plant species by the pest species is being hindered, but it also may result from the effect of the plant on the natural enemies of pests. White mustard produces large amounts of pollen, which constitutes the source of amino acids, carbohydrates, sugars, proteins and other organic and inorganic substances, which are indispensable for the production of energy and laying of the eggs in such predators as hoverflies (Syrphidae), green lacewings (Chrysopidae) [3], ladybirds (Coccinellidae) and also in parasitic wasps [7, 8].

Objective of the study was the evaluation of the effect of white mustard as a companion plant in the cultivation of

broad bean, cultivar Bartek, on the level of plant infestation with black bean aphid (*Aphis fabae* Scop.), and also on the occurrence of its natural enemies.

2. Material and methods

The investigations were conducted in the years 2013 and 2014 in the area of a private agricultural holding in Igołomia village (Malopolska voivodship, 50°06'19.1"N 20°17'07.6"E). The field experiment comprised the following objects: control - broad bean, Bartek cv. as a monotypic cultivation (pure stand), sown at 50 cm x 10 cm spacing (V); broad bean spaced 60 cm x 10 cm with white mustard as the crop intersown between the rows (VSi) and broad bean spaced 50 cm x 10 cm, with a 50 cm wide mustard stripe surrounding the plot (in this case the width of broad bean stripes was 3 m) (VSs). Both our earlier studies and other reports [13] indicate a high competition from the white mustard plants, which leads to the reduction in the seed yield of the main crop. It was the reason, why in the object, where white mustard was intersown between the rows, spacing of the broad beans was wider. The experiment was set up in three replications. The plot area was 12 m^2. *A. fabae* Scop. aphid population was monitored **since** the period when the first winged migrants were settled on the plants and the monitoring was continued once a week during the whole period of aphid presence. All larvae, wingless females and winged migrants were counted on 15 randomly selected plants in each plot. Aphid colonies were analyzed for the presence of all development stages (eggs, larvae, pupae and adult specimens) of predatory Diptera, Syrphidae; Coleoptera, Coccinellidae; Neuroptera, Chrysopidae; Heteroptera, Anthocoridae and Aranea. Occurrence of ants (Hymenoptera, Formicidae) and mummies of parasited aphids was also noted.

The significance of differences between means was tested via conducting single factor variance analysis (cultivation system) and two factor variance analysis (cultivation system x year) with the use of the Statistica 12.0 PL software. The means were differentiated using the NIR Fisher test at the significance level of $\alpha = 0.05$.

3. Results and discussion

The dynamics of aphid occurrence in 2013 and 2014 seasons indicated their relatively late appearance on the host plant i.e. in May/June (Fig. 1). In the 2013 season its number remained at a stable, low level during the entire period of observations, whereas in the 2014 season the aphids exhibited the peak of abundance during the second and third part of June. Intensification of black bean aphid occurrence on broad bean differed significantly depending on the year of study and also the sowing system. The mean number of aphids per plant during season was several fold higher in 2014 than 2013 (Table 1, Fig. 2). On the other hand, independently of the experimental season, significantly greater number of aphids was observed for monotypic cultivation, than when the broad beans plants were accompanied by white mustard. Furthermore, during the 2013 season it was found, that more favorable effect of mustard on the limiting of the occurrence of aphids took place when *S. alba* was sown in form of a strip surrounding the plot than in the form of intercropping in interrows of broad beans (Table 1). The course of the dynamics of aphid occurrence on individual objects indicated stronger inhibitory effect of white mustard during the highest intensity of aphid occurrence (2014) and in the final period (2013 and 2014). In this period of growth, mustard begins to grow above the broad bean plants and the mechanism hindering the migrating pests to find the host plant during secondary infestations begins to have a stronger effect. Moreover, the luring role of the flowers towards predatory and parasitic insects may come into play here.

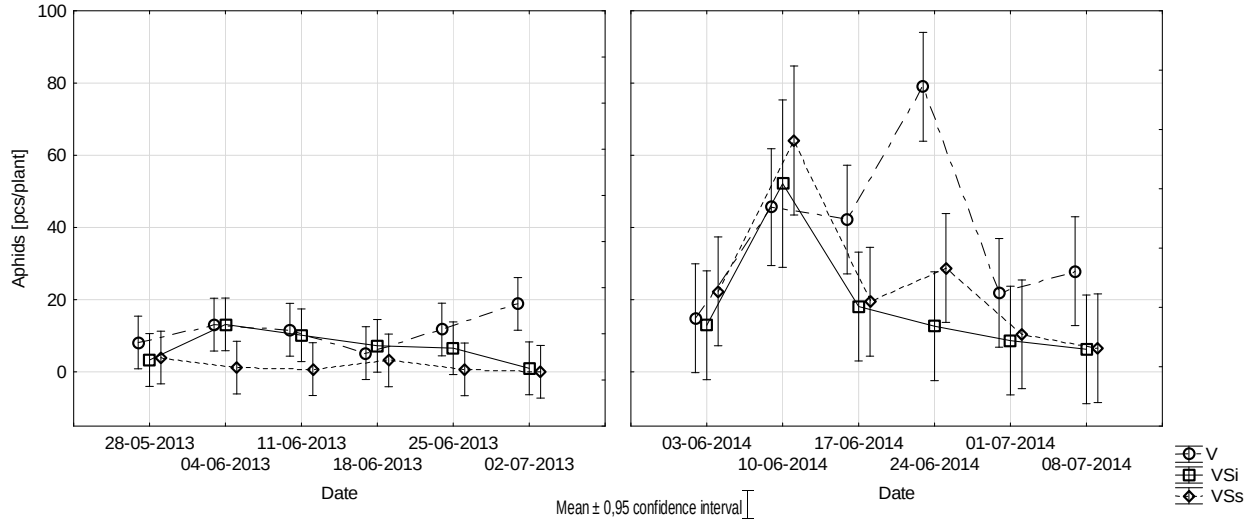

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Fig. 1. The dynamics of aphids (*Aphis fabae* Scop.) occurrence on broad bean plants depending on sowing system. V – control – broad bean as a monotypic cultivation , VSi – broad bean + mustard in interrows, VSs – broad bean + mustard in strips.

Rys. 1. Dynamika występowania mszycy burakowej (*Aphis fabae* Scop.) *na roślinach bobu zależnie od sposobu wysiewu. V – kontrola – bób w uprawie jednogatunkowej, VSi – bób + gorczyca w międzyrzędziach, VSs – bób + gorczyca jako pas dookoła poletka.*

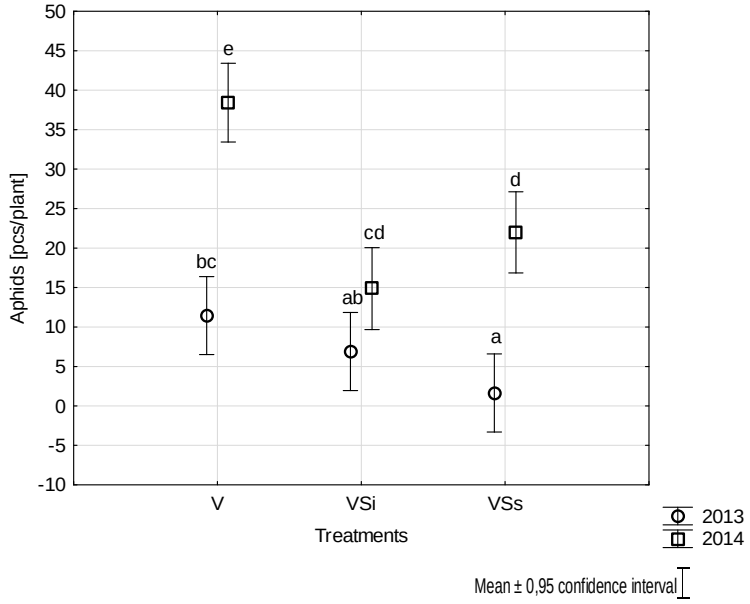
Table 1. Occurrence of aphids (*Aphis fabae* Scop.), its natural enemies and Formicidae [pcs/plant] on broad bean plants depending on sowing system

Tab. 1. Występowanie mszycy burakowej (*Aphis fabae* Scop.)*, jej wrogów naturalnych oraz mrówek na roślinach bobu zależnie od sposobu wysiewu*

Specification	V*	VSi	VSs
Mean number of aphids per plant	11.448 c**	6.896 b	1.644 a
	38.420 b	14.864 a	21.987 a
Mean number of *Syrphidae* eggs per plant	0.0037 a	0.0000 a	0.0185 a
	0.0000 a	0.0000 a	0.0000 a
Mean number of *Syrphidae* larvae per plant	0.0667 b	0.0111 ab	0.0000 a
	0.0000 a	0.0296 a	0.0000 a
Mean number of *Coccinellidae* eggs (layers) per plant	0.0037 a	0.0037 a	0.0000 a
	0.0000 a	0.0000 a	0.0074 a
Mean number of *Coccinellidae* larvae per plant	0.0704 b	0.0148 a	0.0074 a
	0.1185 a	0.0815 a	0.1222 a
Mean number of *Coccinellidae* adults per plant	0.0667 b	0.0259 a	0.0000 a
	0.0852 b	0.0222 a	0.0259 a
Mean number of *Chrysopidae* eggs per plant	0.0074 a	0.0000 a	0.0074 a
	0.0000 a	0.0000 a	0.0000 a
Mean number of *Chrysopidae* larvae per plant	0.0000 a	0.0074 a	0.0000 a
	0.0074 a	0.0000 a	0.0037 a
Mean number of *Formicidae* per plant	0.4037 b	0.0481 a	0.0296 a
	0.0296 a	0.0259 a	0.0370 a
Mean number of *Aranea* per plant	0.0407 a	0.0296 a	0.0111 a
	0.0519 b	0.0074 a	0.0074 a
Mean number of *Anthocoridae* per plant	0.0148 a	0.0037 a	0.0000 a
	0.0000 a	0.0074 a	0.0037 a
Mean number of mummies of parasitized aphids per plant	0.0074 a	0.0148 a	0.0000 a
	0.0111 a	0.0000 a	0.0037 a

* V – control – broad bean as a monotypic cultivation, VSi – broad bean + mustard in interrows, VSs – broad bean + mustard in strips
**Means marked with the same letter in lines do not differ statistically at $p < 0.05$. Upper and lower values relate to experiments from 2013 and 2014, respectively

Source: own work / Źródło: opracowanie własne



Effects	SS*	df	MS	F	p
Sowing system	65126	2	32562.9	19.0169	0.000000
Year	132807	1	132807.4	77.5601	0.000000
Sowing system x year	24237	2	12118.3	7.0771	0.000872

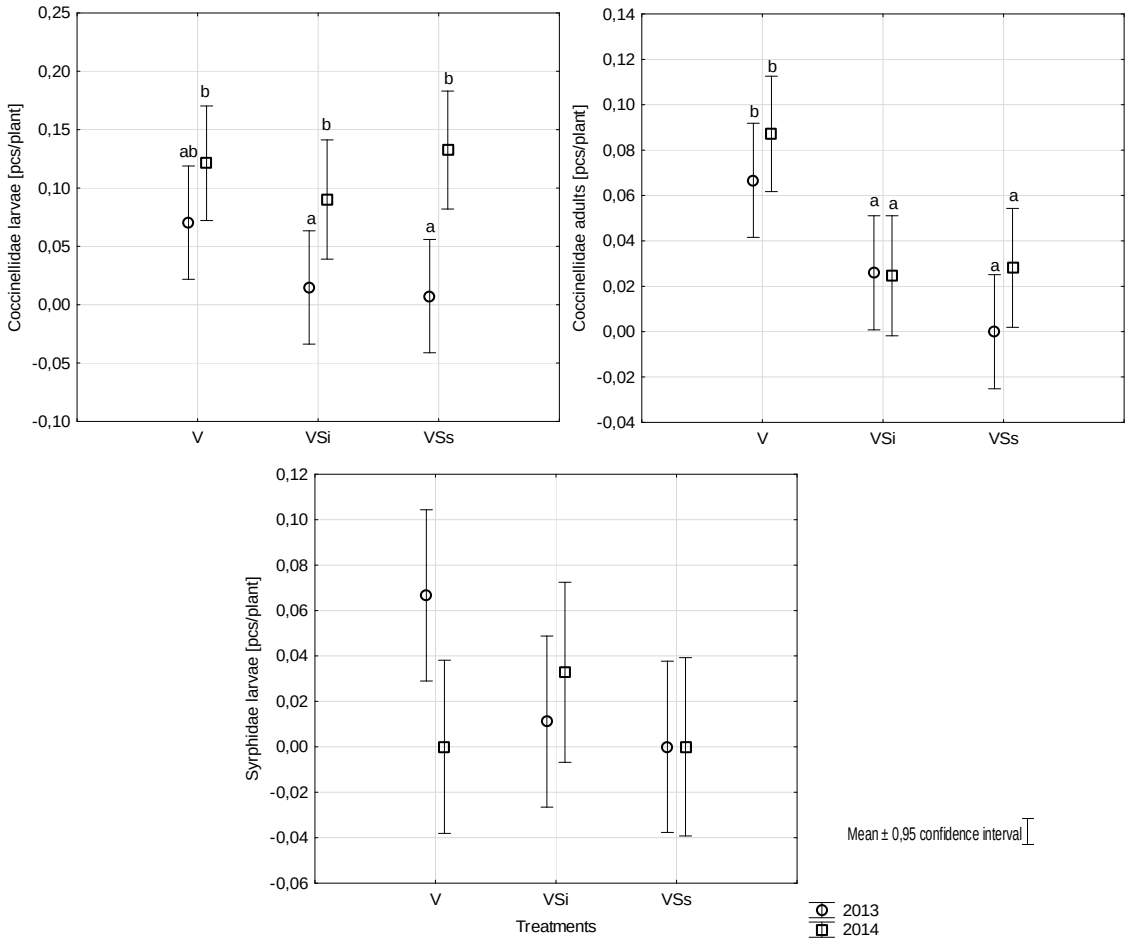
*SS – sum of squares, df – degrees of freedom, MS – mean squares, F – Fisher – Snedecor's test, p – probability level

Source: own work / Źródło: opracowanie własne

Fig. 2. Mean number of aphids (*Aphis fabae* Scop.) on broad bean plants depending on sowing system. Explanation as in figure 1. Mean followed by the same letter are not significantly different at $p < 0.05$

Rys. 2. Średnia liczba mszyc (*Aphis fabae Scop*)*. na roślinach bobu zależnie od sposobu wysiewu. Objaśnienia jak na rys. 1. Średnie oznaczone takimi samymi literami nie różnią się istotnie przy p < 0.05*

The analysis of occurrence of aphid predators only in the case of adult ladybirds, in both study years, demonstrated their significantly higher number on the broad bean plants in a monotypic cultivation, which is not surprising considering the fact, that they were infested by aphids to a greater extent (Table 1, Fig. 3). On the contrary, no such relationships were observed for the larval stages of the main aphid predators, i.e. hoverflies and ladybirds. More of these predators were found on control plants only in the 2013 season. Analysis of the data from both study years did not demonstrate a significant influence of the broad bean sowing system on their occurrence. The mean number of aphids per one predator in the case of these two aphid predator groups was more favorable under the conditions of broad bean cultivation with mustard (Fig. 4). No significant differences between the studied objects were found in the numbers of Anthocoridae, Chrysopidae and parasited aphid mummies. In one of the seasons, also a higher number of spiders (2014) and ants (2013) were found on the control plants.



Effects	SS*	df	MS	F	p
Coccinellidae larvae					
Year	2.7444	1	2.744422	16.58213	0.000049
Sowing system	0.4978	2	0.248891	1.50383	0.222599
Sowing system x year	0.3753	2	0.187650	1.13380	0.322071
Coccinellidae adults					
Year	0.09693	1	0.096934	2.18440	0.139617
Sowing system	1.18586	2	0.592931	13.36162	0.000002
Sowing system x year	0.06016	2	0.030082	0.67789	0.507836
Syrphidae larvae					
Year	0.0880	1	0.087957	0.882934	0.347545
Sowing system	0.3009	2	0.150454	1.510307	0.221165
Sowing system x year	0.5577	2	0.278857	2.799247	0.061161

*SS – sum of squares, df – degrees of freedom, MS – mean squares, F – Fisher – Snedecor's test, p – probability level

Source: own work / Źródło: opracowanie własne

Fig. 3. Mean number of natural enemies of aphids (*Aphis fabae* Scop.) on broad bean plants depending on sowing system. Explanation as in figure 1. Mean followed by the same letter are not significantly different at $p < 0.05$.
Rys. 3. Średnia liczba wrogów naturalnych mszycy burakowej (*Aphis fabae Scop*). *na roślinach bobu zależnie od sposobu wysiewu. Objaśnienia jak na rysunku 1. Średnie oznaczone takimi samymi literami nie różnią się istotnie przy p < 0.05.*

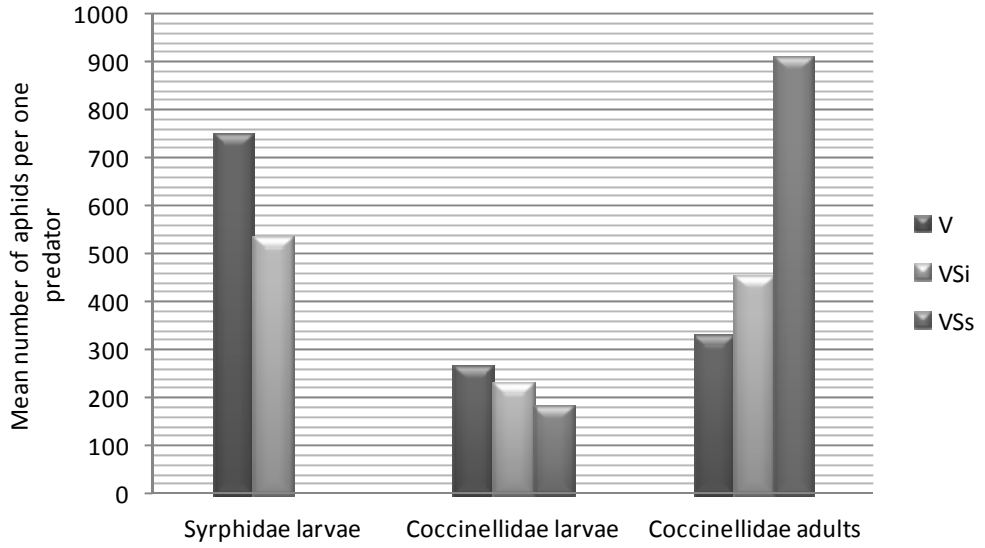


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Fig. 4. Mean number of aphids (*Aphis fabae* Scop.) per one predator (Syrphidae larva or Coccinellidae larva or Coccinellidae adult) depending on sowing system. Explanation as in figure 1.
Rys. 4. Średnia liczba mszyc (*Aphis fabae* Scop.) *przypadająca na jednego drapieżcę (larwę bzygowatych, larwę biedronkowatych lub postać dorosłą biedronkowatych) zależnie od sposobu wysiewu. Objaśnienia jak na rys. 1.*

As indicated by studies, the number of black bean aphid can be efficiently limited by intercropping. The mean *A. fabae* number on the field beans plants, as well as number of infested plants was significantly reduced by intercropping with spring wheat and spring barley [6]. In the faba bean cultivation accompanied by basil (*Occimum basilicum* L.) and *Staureja hortensis* L. [2] as well as dragonhead (*Dracocephalum moldavica* L.) [1], the abundance of *A. fabae* was significantly lower than in the monotypic cultivation. In the latter case it was further determined, that the population density of the most common ladybirds *Hippodamia variegata* Goeze and *Coccinella septempunctata* L. was higher in this plant combination than in the monotypic cultivation. In our study, white mustard also contributed to a decrease in average number of aphids per a single plant, however, an unambiguous effect of the plant on natural enemies of the pest was not found. It should be however emphasized, that both the number of aphids, as well as the accompanying predators and ants was low. As it is widely known, the number of aphids on the broad bean may considerably fluctuate between experimental seasons, often reaching the number of over several hundred individuals per plant [5]. The majority of aphid predators require specific prey density (as an example, for *Coccinella septempunctata* L. this density amounts to 10 aphids per m^2), for them to colonize a given environment [5], therefore such a low aphid density as in the present study, could be the reason for the lack of clear effect of white mustard on the occurrence of natural enemies of the pest.

4. Conclusions

1. Broad bean cultivation in combination with intercropping white mustard, as well as in the form of surrounding sowing contributed to a significant decrease of black bean aphid abundance on the broad bean plants. The effect was visible mainly during the final period of the pest occurrence (i.e. third decade of June and first decade of July).

2. The analysis of the occurrence of natural enemies of *A. fabae* demonstrated a strong relationship between the number of adult Coccinellidae with the number of aphid and their highest numbers in the monotypic broad bean cultivation. On the other hand, the predator to prey ratio in the case of larval stages of the major aphid predators, i.e. Syrphidae and Coccinellidae was more favorable in the presence of mustard as the companion plant.

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